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[Designation of Document] SPECIFICATION

[Title of the Invention] HEAD DRIVE APPARATUS AND METHOD FOR INKJET PRINTER

[Claims]

[Claim 1] In a head drive apparatus, for an inkjet printer, in which a piezoelectric element provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive apparatus for an inkjet printer is characterized by comprising

a capacitor for applying an intermediate potential to a ground-side electrode of each piezoelectric element and a charge circuit for charging said capacitor utilizing the drive signal from the head drive circuit.

[Claim 2] A head drive apparatus for an inkjet printer according to claim 1, characterized in that said charge circuit has a switch circuit for applying the intermediate potential of the drive signal to the capacitor with a different timing from the print timing of each piezoelectric element and thus charging the capacitor.

[Claim 3] A head drive apparatus for an inkjet printer according to claim 2, characterized in that said switch circuit is a switching element.

[Claim 4] A head drive apparatus for an inkjet printer according to claim 2 or 3, characterized in that said switching element is controlled based on the drive signal.

[Claim 5] In a head drive method, for an inkjet printer, in which a piezoelectric element provided to correspond to each of plural nozzles is

selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive method for an inkjet printer is characterized in that

a capacitor connected to a ground-side electrode of each piezoelectric element is charged by a charge circuit utilizing the drive signal from the head drive circuit, thus applying an intermediate potential to the ground-side electrode of each piezoelectric element.

[Claim 6] A head drive method for an inkjet printer according to claim 5, characterized in that said charge circuit has a switch circuit for applying the intermediate potential of the drive signal to the capacitor with a different timing from the print timing of each piezoelectric element and thus charging the capacitor.

[Claim 7] A head drive method for an inkjet printer according to claim 6, characterized in that said switch circuit is a switching element.

[Claim 8] A head drive method for an inkjet printer according to claim 7, characterized in that said switching element is controlled based on the drive signal.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a head drive technique, for an inkjet printer, configured such that the ground side of piezoelectric elements provided to correspond to nozzles for ejecting ink droplets is held at an intermediate potential.

[0002]

[Prior Art]

Conventionally, an inkjet color printer of the type in which inks of several colors are ejected from a printhead has prevailed as an output apparatus of a computer and has been widely used to print an image processed by the computer or the like in multiple colors and tones.

[0003]

For example, an inkjet printer using a piezoelectric element as a drive element for ejecting ink is configured as follows. Plural piezoelectric elements provided to correspond to plural nozzles of a printhead are selectively driven. Thereby, ink droplets are ejected through the nozzles based on the dynamic pressure of the individual piezoelectric elements and adhered to print paper. Thereby, dots are formed on the print paper, thus performing printing.

[0004]

Here, each piezoelectric element, provided to correspond to each nozzle for ejecting an ink droplet, is driven based on a drive signal supplied from a driver IC (head drive circuit) mounted in a printer body or the printhead, thus ejecting an ink droplet.

[0005]

In the meantime, in such a piezoelectric element, during non-drive (i.e. when printing is not performed), electric charge stored by charging are discharged due to insulation resistance and the voltage of the piezoelectric element is lowered, thereby affecting the ink ejection in some cases.

[0006]

Consequently, Japanese Patent No. 3097155 obtained by the present

inventor discloses a head drive apparatus and method configured such that a charge voltage is applied to the piezoelectric element with a different timing from the drive timing, thus maintaining the charge voltage.

[0007]

[Problems that the Invention is to Solve]

However, in such head drive for the inkjet printer, the drive signal applied to each piezoelectric element is configured, for example, to be set to a high voltage during non-drive and have the voltage lowered during drive. In this case, power consumption becomes large and a voltage applied to the piezoelectric element becomes comparatively high, so that a voltage drop due to the aforesaid discharging is also large.

[0008]

There is also a head drive method such that the ground side of each piezoelectric element is held at a certain fixed potential of the drive signal. According to such a head drive method, it is possible to prevent the discharge between the electrodes of the piezoelectric elements that occurs upon the aforesaid increase in density. However, in correspondence to variation in the drive signal, the voltage need be varied, and charging and discharging need be switched, so that a bi-directional variable power supply will be needed.

[0009]

Consequently, an object of the invention is to provide a head drive apparatus and method, for an inkjet printer, configured such as to be able to easily hold the intermediate potential of each piezoelectric element, with a simple configuration.

[0010]

[Means for Solving the Problems]

To solve the aforesaid problems, in the invention, an intermediate potential from a capacitor charged by a charge circuit is applied to a ground-side electrode of each piezoelectric element, thus holding the ground side of each piezoelectric element at a higher potential than a ground potential.

[0011]

That is, in the head drive apparatus for an inkjet printer of claim 1, in which a piezoelectric element provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive apparatus for an inkjet printer is characterized by comprising a capacitor for applying an intermediate potential to a ground-side electrode of each piezoelectric element and a charge circuit for charging the aforesaid capacitor utilizing the drive signal from the head drive circuit.

[0012]

Besides, in the head drive method for an inkjet printer of claim 5, in which a piezoelectric element provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal from a head drive circuit, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive method for an inkjet printer is characterized in that a capacitor connected to a ground-side electrode of each piezoelectric element is charged by a charge circuit utilizing the drive signal from the head drive circuit, thus applying an intermediate potential to the ground-side electrode of each piezoelectric element.

[0013]

According to this configuration, the charge circuit charges the capacitor utilizing the drive signal. Therefore, based on the charge voltage of this capacitor, the intermediate potential is applied to the ground-side electrode of the piezoelectric element. Thereby, the ground-side electrode of the piezoelectric element is held at the intermediate potential. Accordingly, a voltage applied between both electrodes of the piezoelectric element becomes substantially zero. Thus, power consumption is reduced and a voltage drop due to natural discharge of the piezoelectric element is small, so that a power loss is reduced.

[0014]

The head drive apparatus of claim 2 is characterized in that the aforesaid charge circuit has a switch circuit for applying the intermediate potential of the drive signal to the capacitor with a different timing from the print timing of each piezoelectric element and thus charging the capacitor.

[0015]

The head drive method of claim 6 is characterized in that the aforesaid charge circuit has a switch circuit for applying the intermediate potential of the drive signal to the capacitor with a different timing from the print timing of each piezoelectric element and thus charging the capacitor.

[0016]

According to this configuration, the switch circuit applies the intermediate potential of the drive signal to the capacitor with a different timing from the print timing of each piezoelectric element. Therefore, the ground-side electrode of the piezoelectric element is held at this intermediate potential by

the intermediate potential applied by the capacitor.

[0017]

The head drive apparatus of claim 3 is characterized in that the aforesaid switch circuit is a switching element.

[0018]

The head drive method of claim 7 is characterized in that the aforesaid switch circuit is a switching element.

[0019]

According to this configuration, the switching element is controlled to thereby apply the intermediate potential of the drive signal to the capacitor. Therefore, a minute signal suffices to control the switching element, so that the switching element i.e. the switch circuit can be easily controlled.

[0020]

The head drive apparatus of claim 4 is characterized in that the aforesaid switching element is controlled based on the drive signal.

[0021]

The head drive method of claim 8 is characterized in that the aforesaid switching element is controlled based on the drive signal.

[0022]

According to this configuration, the switching element is controlled, based on the drive signal, in accordance with the waveform of the drive signal. Thereby, the capacitor can be charged by easily applying the intermediate potential of the drive signal to the capacitor.

[0023]

[Mode for Carrying out the Invention]

A head drive apparatus according to embodiments of the invention will be described with reference to the drawings. Additionally, since the embodiments to be described below are preferred embodiments of the invention, various technically preferable limitations are put thereon. However, the scope of the invention is not limited to these embodiments unless the following description specifically states any limitation on the invention.

[0024]

Fig. 1 shows the configuration of an embodiment of the head drive apparatus according to the invention. In Fig. 1, the head drive apparatus 10 comprises: a piezoelectric element 11 provided to correspond to each of plural nozzles of an inkjet printer; a head drive circuit 12 for supplying a drive signal to one-side electrode 11a of each piezoelectric element 11; a current amplifying circuit 13 and a switch circuit 14 that are provided between this head drive circuit 12 and each piezoelectric element 11; and a capacitor 20 and a charge circuit 21 that apply a predetermined voltage to the other, ground-side electrode 11b of each piezoelectric element 11.

[0025]

Here, Fig. 1 shows only one piezoelectric element 11. However, actually, a head of the inkjet printer is provided with plural nozzles and one piezoelectric element is provided to correspond to each nozzle. And, the drive signal COM from the head drive circuit 12 is sequentially outputted to each piezoelectric element 11, actually via a shift register or the like.

[0026]

The piezoelectric element 11, which is a piezo-element for example, is configured to be displaced by a voltage applied between both electrodes 11a

and 11b. And, the piezoelectric element 11 is always charged in the vicinity of an intermediate potential Vc. When discharged based on the drive signal from the head drive circuit 12, the piezoelectric element 11 is configured to pressurize ink in the corresponding nozzle to thereby eject an ink droplet through this nozzle.

[0027]

The head drive circuit 12, configured as a driver IC, generates the drive signal COM for the head of the inkjet printer and is disposed in a printer body for example. The current amplifying circuit 13 comprises two transistors: a first transistor 15 and a second transistor 16.

[0028]

The first transistor 15 has a collector connected to a constant voltage power supply, a base connected to the output of the head drive circuit 12, and an emitter connected to the input side of the switch circuit 14. Thereby, electrical conduction is established based on a signal from the head drive circuit 12, thus supplying a constant voltage to the piezoelectric element 11 via the switch circuit 14.

[0029]

Besides, the second transistor 16 has an emitter connected to the input side of the switch circuit 15, a base connected to the output of the head drive circuit 12, and a collector connected to ground. Thereby, electrical conduction is established based on a signal from the head drive circuit 12, thus discharging the piezoelectric element 11 via the switch circuit 14.

[0030]

Upon receipt of a control signal, the switch circuit 14 is turned on with

the drive timing of the corresponding piezoelectric element 11, thus outputting the drive signal COM to the piezoelectric element 11. The capacitor 20, in order to apply its charge voltage i.e. a bias voltage Vb to the ground-side electrode 11b of each piezoelectric element 11, has one end connected to the ground-side common electrode 11b of the piezoelectric element 11, and the other end connected to ground.

[0031]

Additionally, to be able to supply the stable bias voltage to each piezoelectric element 11, the capacity of the first capacitor 20 is selected to be sufficiently greater than the total capacitance (about several μF) of all the electrostatic elements 11, for example, about several hundreds μF to several thousands μF.

[0032]

The aforesaid charge circuit 21 comprises a switch 22 and a control circuit 23. The switch circuit 22 includes a switching element 22a out of various switching elements such for example as a transistor, an FET, a thyristor, and a triac. Based on the drive signal COM from the head drive circuit 12, as shown in Fig. 2, the control circuit 23 is configured to turn on the switch circuit 22 with a different timing from the print timing of the drive signal COM, i.e., when the drive signal COM stands at the intermediate potential. Additionally, at the time of print start, the control circuit 23 turns on the switch circuit 22 to gradually raise the potential of the capacitor 20 to the intermediate potential Vc.

[0033]

The head drive apparatus 10 according to this embodiment is configured as aforesaid and operates as follows based on the head drive

method according to the invention. The piezoelectric element 11 driven during printing will first be described. At the time of print start of the inkjet printer, as shown in Fig. 3A, a charge signal NCHG is inverted to an L level for a time period of 100 μs for example. Thereby, the potential of the drive signal COM from the head drive circuit 12 is raised to the intermediate potential Vc, as shown in Fig. 3A.

[0034]

Thereby, the drive signal COM causes a current to flow from the first transistor 15 of the current amplifying circuit 13 via the switch circuit 14 to the one-side electrode 11a of the piezoelectric element 11, thus charging the one-side electrode 11a of the piezoelectric element 11. Thereby, the potential of the one-side electrode 11a of the piezoelectric element 11 is raised to the intermediate potential Vc, as shown in solid line in Fig. 3B.

[0035]

AT this time, the control circuit 23 of the charge circuit 21 turns on the switching element 22 of the switch circuit 22, thereby charging the capacitor 20 by the drive signal COM. Thereby, the charge voltage of the capacitor 20 is raised to the intermediate potential Vc. Therefore, as shown in dotted line in Fig. 3B, the potential of the ground-side electrode 11b of the piezoelectric element is also gradually raised to reach the intermediate potential Vc.

[0036]

Here, as shown in Fig. 3B, the potential of the ground-side electrode 11b of the piezoelectric element 11 reaches the intermediate potential similarly to the drive signal COM. Therefore, the potential difference between both electrodes 11a and 11b of the piezoelectric element is held small. Accordingly,

this potential difference is lower than the intermediate potential Vc of the drive signal COM. Thus, the piezoelectric element 11 will not malfunction ejecting an ink droplet.

[0037]

Then, during printing, based on variation in the drive signal COM, when the potential of the drive signal COM is higher than the intermediate potential Vc, the one-side electrode 11a of the piezoelectric element 11 is charged via the first transistor 15 of the current amplifying current 13. Besides, when the potential of the drive signal COM is lower than the intermediate potential Vc, the one-side electrode 11a of the piezoelectric element 11 is discharged via the second transistor 16 of the current amplifying circuit 13. Thereby, the piezoelectric element 11 operates based on the drive signal COM, thus ejecting an ink droplet.

[0038]

On the contrary, as aforesaid, the intermediate potential Vc of the drive signal COM is applied to the capacitor 20 as the switch circuit 22 is turned on. Thus, the capacitor 20 is charged and thereby held at the intermediate potential Vc. Thereby, the capacitor 20 applies the intermediate potential Vc to the other, ground-side common electrode 11b of each piezoelectric element 11. Thereby, the ground-side common electrode 11b is held at the intermediate potential Vc.

[0039]

Accordingly, the potential difference between both electrodes 11a and 11b of each piezoelectric element 11 becomes substantially zero. Furthermore, at the time of print end (END), as shown in Fig. 3A, the drive signal COM from

the head drive circuit 12 is discharged from the one-side electrode 11a of the piezoelectric element 11 via the second transistor 16 of the current amplifying circuit 13. Thereby, the potential of the drive signal COM is lowered to a potential of zero.

[0040]

On the contrary, the one-side electrode 11a of the piezoelectric element 11 that is not driven is always charged to and held at the intermediate potential by the drive signal COM from the head drive circuit 12.

[0041]

Thus, the potential of the ground-side electrode 11b of each piezoelectric element 11 is held at the intermediate potential Vc by the charge voltage of the capacitor 20. Therefore, the potential difference between both electrodes 11a and 11b of the piezoelectric element 11 is held at substantially zero. At the same time, when the driven piezoelectric element and the non-driven piezoelectric element are adjacent to each other, the potential difference between the one-side electrodes 11a of these piezoelectric elements 11 is also held at substantially zero.

[0042]

Furthermore, the capacitor 20 is charged utilizing the intermediate potential Vc of the drive signal COM from the head drive circuit 12. Therefore, there is no particular need of a power supply circuit for generating the intermediate potential Vc.

[0043]

In the aforesaid embodiment, the piezoelectric element 11 uses a piezo-element for example but is not limited thereto. Alternatively, another

piezoelectric element such for example as an electrostriction element or a magneto-striction element may be used.

[0044]

Besides, in the aforesaid embodiment, the charge circuit 21 comprises the switch circuit 22 and the control circuit 23. However, the charge circuit 21 is not limited thereto but can use a charge circuit of another arbitrary configuration if the configuration is made such that only the intermediate potential Vc of the drive signal COM can be supplied to the capacitor 20 with a different timing from the print timing of the drive signal COM.

[0045]

[Advantage of the Invention]

As described above, according to the invention, based on the charge voltage of the capacitor charged by the charge circuit utilizing the intermediate potential of the drive signal, the intermediate potential is applied to the ground-side electrode of the piezoelectric element. Thereby, the ground side of the piezoelectric element is held at the intermediate potential. Accordingly, the voltage applied between both electrodes of the piezoelectric element becomes substantially zero. Thus, power consumption is reduced, and the voltage drop due to natural discharge of the piezoelectric element is small, so that a power loss is reduced.

[Brief Description of the Drawings]

[Fig. 1]

A block diagram showing the configuration of an embodiment of a head drive apparatus according to the invention;

[Fig. 2]

A timing diagram showing (A) a drive signal of a head drive circuit and (B) the on/off of a switch circuit in the head drive apparatus of Fig. 1; and

[Fig. 3]

A timing diagram showing (A) the drive signal and (B) both electrodes of a piezoelectric element in the head drive apparatus of Fig. 1.

[Description of the Reference Numerals and Signs]

10: Head drive apparatus

11: Piezoelectric element

11a: One-side electrode

11b: Ground-side electrode

12: Head drive circuit

13: Current amplifying circuit

14: Switch circuit

15: First transistor

16: Second transistor

20: Capacitor

21: Charge circuit

22: Switch circuit

22a: Switching element

23: Control circuit

[Designation of Document] ABSTRACT

[Abstract]

[Problem] An object of the invention is to provide a head drive apparatus and method, for an inkjet printer, configured such as to be able to easily hold the intermediate potential of each piezoelectric element, with a simple configuration.

[Means for Resolution] In a head drive apparatus 10, for an inkjet printer, in which a piezoelectric element 11, for pressurizing ink, provided to correspond to each of plural nozzles is selectively driven with a predetermined print timing by a drive signal COM from a head drive circuit 12, thus ejecting an ink droplet through the corresponding nozzle to perform printing, the head drive apparatus 10 is configured to comprise a capacitor 20 for applying an intermediate potential Vc to a ground-side electrode 11b of each piezoelectric element and a charge circuit 21 for charging the aforesaid capacitor utilizing the drive signal COM from the head drive circuit.

[Selected Drawing] Fig. 1

Fig. 1

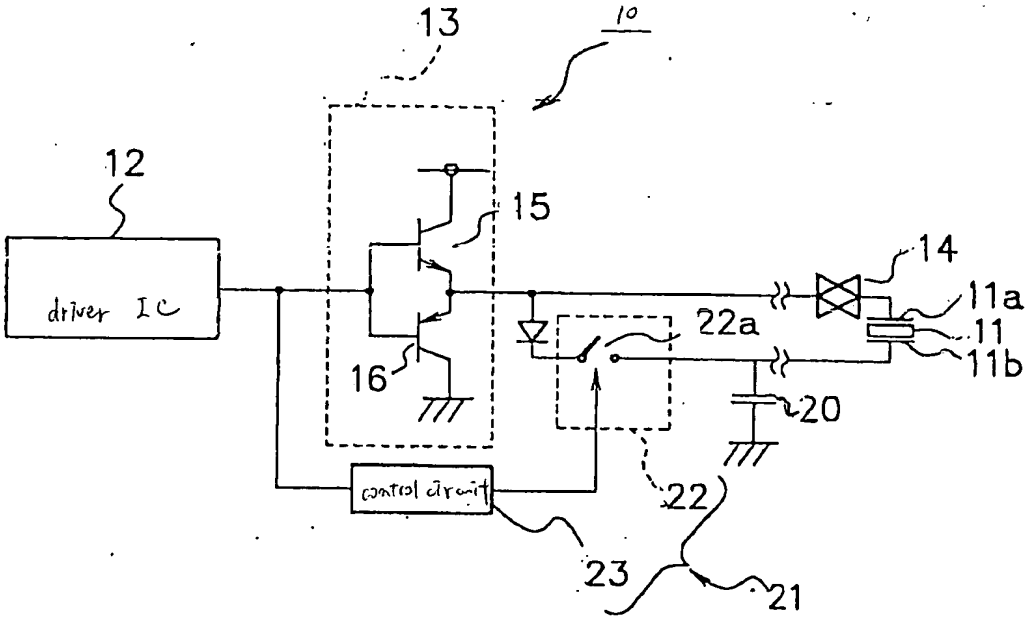

Fig. 2

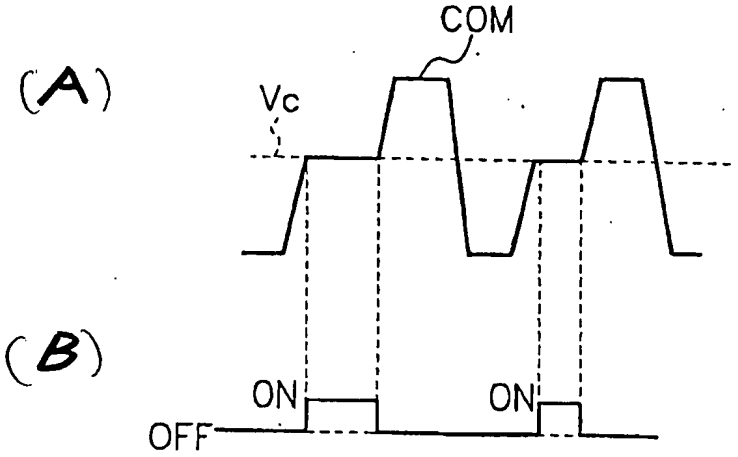

Fig. 3